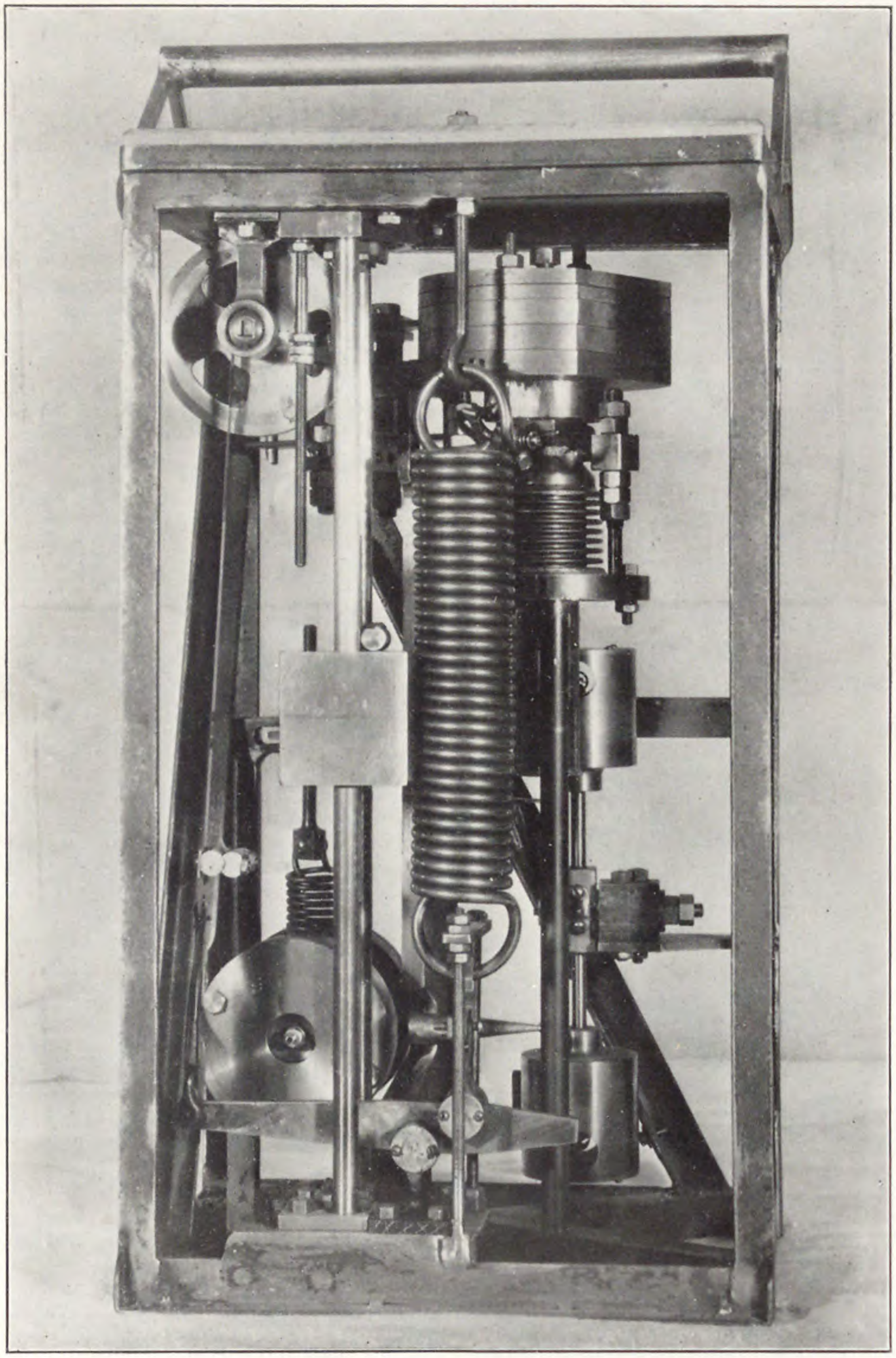
NEWARK ENGINEERING NOTES



Newark College of Engineering presents Story of M.I.T. research on question, "Do we survive how much shock?"—from bus rides to rollercoasters, to airplanes. Partial assembly of complex testing instruments.

Volume 1, No. 1 April, 1938

THE PRESIDENT'S DIARY

This magazine—The debt of the College to the Technical School—The benefits to the community—"Educational Transportation"—Growth of Enrollment.

JANUARY 20th

I have talked today with some members of the Alumni of the Newark College of Engineering and the Newark Technical School about the advisability of issuing a paper which reflects something of the professional contributions of this institution. And by the institution, I mean not only its active staff, but its students and its Alumni as well.

Today, an institution which is forward-looking and properly developing must pay some particular attention to the solution of scientific problems or, to what might be called, original investigation.

Sometimes even those who are close to the institution fail to realize just what is being done here at the college along this particular line. So often there is a failure to appreciate that within the last twenty years there has grown up in connection with this institution, which dates back to 1881, not only an appreciation of scientific values and professional contributions, but some real advance along these particular lines.

This magazine should prove of interest to the alumni and to all friends of the institution. There will be no attempt to make it popular in the sense of entertaining. It is to be hoped, though, that it will be interesting to all alumni who are interested in engineering and scientific progress.

JANUARY 25th

In looking over the last entry, I cannot help but be struck by the contribution of our Technical School toward this whole problem of the development of our professional and scientific work in the College. After all, things are only possible when we have the confidence not only of the student body but of the Alumni and the community as well, and when the writer of this diary came to Newark in 1918, he found these fundamentals already established. While today we perhaps may fail to realize the development which has gradually been going on in connection with the Technical School and the College, no one, as yet, has in any way deprecated the soundness of the instruction which the Newark Technical School gave in the evening, and while sometimes there has been a misunderstanding in the minds of the public concerning the standing and the status of the College, it has never been on account of the failure of the graduates of the Evening School to live up to their responsibilities and capabilities.

FEBRUARY 1st

The thing that looms large in the mind of any educational administrator is the relation of the institution which he heads to the community which he serves. It goes without saying that one serves his clientele in education as he does in law or in medicine, and it goes without saying that the employer as well as the employee of engineering talent benefits, but the more intangible benefit to the general taxpayer is the thing which sometimes needs clarification.

Just how does the community benefit by an institution such as this? Our own philosophy is comparatively simple.

An institution of this kind which does not render a unique service—if it simply duplicates services obtainable in other localities nearby—has no real cause for existence. Its function is to develop talent, to furnish opportunity for aptitude and capacity, and to furnish this absolutely irrespective of the financial position of the student possessing the aptitude, or of his family.

It is a trite but true saying that in America we take our brains where we find them, and the history of our country, if it stands for anything, stands for the fact that all along the financial ladder we find brains. When we find them locally, unaccompanied by enough funds to sustain a formal education at a distance, with its consequent higher costs, our first duty is to take care of them.

The extreme simplicity and efficiency of our institution therefore is reflected in two ways: One, toward the cost to the City and the State, and the other, the cost to the individual.

In my own wanderings about, I have found one institution which I think equals our costs, and that, strangely enough, is located in Scotland.

FEBRUARY 10th

In reading over the entry in my diary under date of the first of February, it seems to me that perhaps the whole question of education might be simplified by referring to it as "educational transportation". . . a man gets in at one point and rides along for four years and gets out at another point.

There are many ways of transportation and many means. There are many good cars, some high priced and some entirely reasonable, and our particular desire is to build a car or to furnish educational transportation which, dollar for dollar, will be as efficient as anything of which we know.

If you want to carry this simile just a little further . . . We put a great deal of stress on the chassis, the frame, and the engine, but perhaps the coach-work is not inclined to be as stylish as in many other cars. After all, I do not know that the General Motors Company is at all ashamed of its Buick; perhaps it is just as proud of its medium priced Buick as it is of its Cadillac. Perhaps down in the hearts of some of the General Motors Officials they think it is just as good a technical job. Even Henry Ford, so far as I can understand it, does not apologize profusely for the cost of his product, and, after all, what we are doing in Newark is about the same sort of thing.

We are striving very hard for those two fundamental things which stand out in engineering—soundness of design, and economy of operation.

MARCH 1st

Today, as we were discussing our plans for the scheduling of classes for the college year 1938-39, I was struck with the realization that the college enrollment has had a remarkable growth since the first class of twenty-three students entered in September 1919.

Since that date we have erected two modern structures containing numerous class rooms, drafting rooms, laboratories, and a gymnasium. We have enlarged and modernized all of our laboratories in the Laboratory Building but, in spite of that increase in our physical facilities I again find that we are faced with the need for further expansion of some of our laboratories to adequately provide for our present students who will enter the Sophomore, Junior and Senior classes in September 1938.

It seems to me that we now have reached the point at which, without radical changes in, and additions to, our present plant, we can not adequately provide for any further increases in our college enrollment. As there are other factors which influence the question of numbers in connection with our growth it seems to me that it might be well to examine its history. Therefore, I have asked Mr. Van Houten, one of the College Alumni, to make a study of our increase over the past fifteen or more years and briefly recount, for the benefit of the Alumni, just what that growth has been and what may be expected in the near future.

VOLUME I NUMBER 1

APRIL, 1938

Printed in U. S. A.

NEWARK ENGINEERING NOTES

Published Monthly, September - June, by

The Newark College of Engineering, Newark, N. J.

Administered by

The Board of Trustees of Schools for
Industrial Education of Newark, N. J.

(FOUNDED, MARCH 1881)

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Do you want to be on our mailing list?

From time to time you will receive a copy of the Newark Engineering Notes. In case you like to receive this magazine regularly, the only thing you have to do is to write us and say so. Address your letter to the Editor, Newark Engineering Notes, Newark College of Engineering, Newark, N. J.

GREAT RANGE PORTABLE VIBRATION INSTRUMENT

Newly combined methods of showing graphically various kinds of vibrations.

By EASTMAN SMITH, M.S., Sc.D.

Associate Professor of Physics, Newark College of Engineering

A human being may detect, thru touch and muscle - sensitivity, motions from a thousandth part of an inch all the way up to a sky-drop in an air-pocket, or the varying descent of an airplane thru thousands of feet. This is approximate. Also the stomach and the semicircular canals detect unbalance. What are the limits? Apparently the human ear can respond to vibrations of less than molecular dimensions (we are told) and the eye does better; while it is only a matter of time and further experiment, before some bold person may report back to the world just what he "feels" from a five-hundred mile lift in a transoceanic U. S. MAIL Rocket.

Vibration-Recording Becomes Popular If one wants a "written message" from a vibration, such as appears periodically in the courtroom, following lawsuits on dynamite blasts, pile-driver tortures, machinery installations, building collapses, pneumatic drills, powder-dump and boiler explosions, and a little artillery practice thrown in, messages might be obtained by holding a fountain pen in the hand, on a piece of paper, and acting natural while the event occurs. Anyone knows that a letter written on a lively railroad train, or a motor bus, would make a very good incriminating piece or evidence.

So, also, a letter written aboard a steamship. (Vocational advisers of our engineering youth might point out the still unsolved problem of steamship propeller vibration; in hopes of somebody's new thesis on the nodes and antinodes of deck trembling in various stateroom locations—and what to do about it. There's a gold mine in that.)

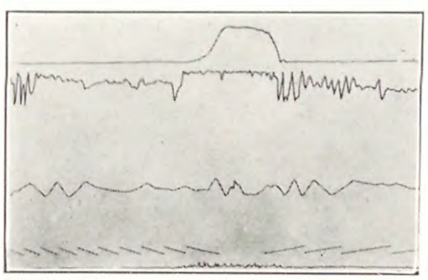
Which Types of Instruments?

It would not be supposed that the handwritten record is free from a personal bias. Some courtroom instruments are no better. One good feature of pen-and-paper, however, is *portability*.

The Desire for Accuracy. Ouija Boards and Planchettes do not make the very best "recording vibration instruments." The desire-to-record does not constitute a scientific experiment. A few years ago there appeared a beautifully machined instrument, intended as an accelerometer in connection with automobile riding comfort; equipped with pencil and spring and weight, plus stop-bumpers for the weight in action. In truth, having nothing to do with accelerations, it may have been a seismograph for smaller motions, and an entertainment for the larger. This had been preceded, in another section of the country, by a partly similar instrument, on good authority, which was elaborately equipped with some kind of return-motion bumper springs, as nearly as one could guess from the published drawings, and which we might call "the football instrument." If the automobile would not make a good record, then the weight-and-pencil would get "footballed" anyhow, and there was a great record. It was intended that the record should "somehow" correspond to riding quality —whatever that is.

Simple Instruments vs. Guesswork. As with sound intensity, light, or electric shock, the average human appears unable to judge accurately of absolute values of acceleration and impact; and of constant velocity travel with eyes shut, not at all. Thus, "any accuracy is good accuracy"—seems to be excuse for building seismographs. But not good ones. And accelerometers are more difficult.

Inventory. But seismometry, including seismographs and accelerometers, involves more than simple *motions*, and *accelerations* or *shocks*. There are *three components* of each; which calls for six instruments. This might satisfy the judge, but not an active engineering opposition. There are three components of *rotational motion;* and three components of *rotational acceleration.* Here are twelve instruments, nicely synchronized. Or else, a lot of computation.



One awful shock registered on Rollercoaster. Mechanic and Smith-Instruments, strapped in rapidly spinning amusement tub, atop roller car, both experience reverse spin.
(Short lines show spin.)
Dangerous curve shows thrill. Airplane stunts could be recorded similarly.

Seismometers have a way of being limited in *range*. A sensitive seismograph at an earthquake epicenter may be wrecked. The range of a less magnifying portable seismograph may be from, say 0.001 inch up to 0.1 inch. Beyond this might be a hundred-to-one range, on an interstate bus, of 0.1 inch to 10 inches. On an ocean steamship, 10 inches to 80 feet. More, for an airliner. Now, in a ten inch portable instrument, anything bigger than ten inches will cause the top or bottom of the cage to collide with the inertia element. The latter is supposed to want to remain still while the rest of the world dances around it. It doesn't succeed—at all—but that is another story. So we just calculate, approximately, or extrapolate. Take two ranges. And these, in three components. Also, accelerometers frim 0.1 (gravitational accel.) to g; and from g to $10g$. For rotational seismographs, 0.1 degree to 10; from 10 to infinity (!) Infinity, that is, excepting that our old friend Friction comes along. At any rate, nobody wants infinity.

Any Limit? This makes twenty-four proposed instruments, all assembled in a space of one cubic foot. A direct recording paper, read by the eye, would be 24 inches high (in the 10-inch space allowed.) Omitting this difficulty, which is really unimportant, there remain, in addition to these various motions, accelerations, shakings, tippings, twists, turns, impacts, and shocks, of diversified pedigrees and assorted magnitudes, yet a record of some element of machinery not transmitting vibrations, but reached by a steel connecting wire; the fine vibrations of a small object, as a surgeon's eye-drill, which have little energy, reached by a wire or aluminum tube; a steady coordinate of time; time-scale marks, twentieths of a second, and one-second marks; signals from the operator, to mark events, and cross-connected electrically with other comparison or calibration instruments; room for writing; and two steady "zero-lines."

We have, now, about 32 indicator plots, simultaneously on one record about 10 inches high; or, a movie film.

You Can't Have Everything. Probably 30 instruments will be occupying the same space at the same time. And, \$100.00 to \$1,000.00 per instrument? (Discussion of costs will be purposely omitted.) We are already omitting: *velocities* of motion, and *rates of change* of accelerations. As for *frequencies*, they can be observed; also *durations* of accelerations and of motions.

In a mechanically recording instrument, the 24 main recording divisions will weigh a thousand pounds, easily. One aim of the design is to have a porter pick it up and place it on the front seat of an automobile being tested!

A Story of Optics and a Hot Day

Why Not An Optical Instrument? Why not an electrical one? Surely a great fundamental difficulty of *magnification*. An experience of the author's may apply.

An excellent optical instrument was kindly lent to him, for tests on underground installations affected by street traffic. At the location, a great many trucks passed. For sufficient reasons, the author had designed and built a number of all-mechanical vibration-recording instruments. The test was at sidewalk level, on a hot summer's day. There was a p a r t n e r; and adequate transportation, guaranteed. The latter turned out to be very necessary, as well as the partner.

The author's instrument consisted of: a 6 volt dry battery box, and small tools; and the assembly of instruments in one foot square by one-and-a-half foot high, weighing 120 pounds—the weight of a small person on the seat cushion of an automobile, or a standard riding test. When this instrument (which we will call assembly "A") was placed on the sidewalk, opened, unlocked, and switched on, records were taken immediately.

A truck was sent for the optical instrument. (This we will call instrument "O.")

While instrument "A" contained 7 selected component instruments, with time and signaling devices, to a total of 12 lines, which were on prepared paper with brass stylus points,—the borrowed instrument "O" was simply a three-component seismograph.

An Optical Instrument "At Work." (The author is not prejudiced against optical instruments.) First there was the storage battery, which was heavy. It failed to drive its motor with the constant speed. "A" was equipped to calibrate—which it did, by running electric connections to instrument "O" in order to figure a time scale for "O's" variable motor. On the truck came the separate, heavy, motor-and-photographic-film assembly. Then, the three-component assembly; heavy too. Also, photographic developing trays and materials; to make immediate check on results.

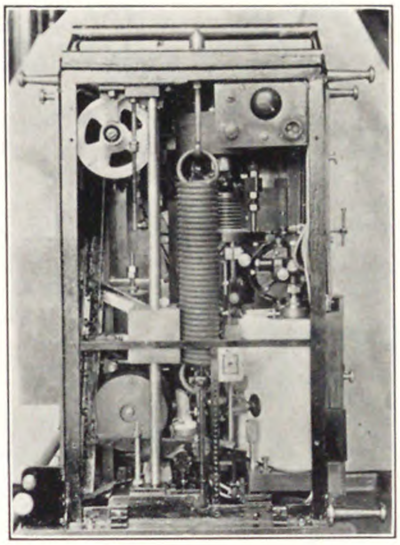
Also, a very excellent TENT! This was of heavy canvas, and heavy iron pipe, about 10 feet long. This had to be pitched over the hot sidewalk. (Partner inside.) Soon, a hot wind blew up.

The indicator and recorder were at opposite ends, aligned with light-beams between. No leakage of light from outside. Partner did all his work in utter darkness. It consumed all of a long morning, to get several records. He also developed many yards of print in a small tray, in the dark, lying down on hot bricks—but with perfect results. Some men are much to be admired.

Mechanics Wins

Vibration Design. It seems that all vibration recording instruments h a v e *mechanical features*. After an electrical magnification come heavy-instrument mechanical reproducing elements. The great difficulties of all-mechanical construction were accepted as a challenge by the author; and the many handy advantages thereof were a goal to achieve.

In some measure, the author feels that the difficulties have been overcome. A satisfactory, all mechanical, light-weight, low-cost, quickly-operable, sufficiently accurate, handy, instantly-visible recording, all-purpose, and rugged assembly of experimental instruments was built, recently, in connection with the MASSACHUSETTS INSTITUTE OF TECHNOLOGY. Comparative tests were made on



cars, trucks, buses, buildings, bridges, elevators, rollercoasters, a motorboat, and steamboats.

High Magnification At Newark. Following this, the author directed the construction of a semi-portable, demonstration-seismoscope; which was built by the students at the NEWARK COLLEGE OF ENGINEERING. Its sensitivity is such that a person walking 50 feet away has been indicated. On college "Visitors Day" this sensitivity is too great, and a lower magnification must be used.

Editor's Note: Eastman Smith was born in 1897, at Springfield, Mass. During 1910 and 1911 he studied art, music, and languages in Europe. After two years at Harvard he enlisted as wartime ambulance driver in France. Then followed:

Massachusetts Institute of Technology, S.B., 1922.

5 years experience, machine shop, design, efficiency, and editing; and symphony orchestra.

Lecturer in General Science, New York University, 1927 to 30.

Massachusetts Institute of Technology, M.S., 1931; duPont Research Fellowship, 1931-2; Sc.D., 1934.

Opitical research, Mass. Eye-Ear Inf. He married Alice Greenfield Upham in 1933—moving to Chatham, N. J. Appointed Asst. Prof. of Physics at the Newark College of Engineering in 1933, and Assoc. Prof. in 1935. He is a member of A. S. M. E., and Sigma Xi.

PARALLELS IN PROGRESS

In looking over the names of the faculty and instructing staff, one is impressed with the number of men who are products of some of the best known institutions in the country. These men all joined the instructing staff of the College during its early days and have progressed with the College as the years rolled by.

Massachusetts Institute of Technology gave us Allan R. Cullimore, our first Dean and now President of the institution. Harold N. Cummings, now Professor in Civil Engineering, is also a product of M. I. T. Yale University contributed J. Ansel Brooks, now Professor in Industrial Engineering and Bedross S. Koshkarian, Professor in Theoretical and Applied Mechanics. Harvard University sent James A. Bradley, now Dean of the College, and Associate Professor in Chemistry, while Princeton furnished Frank N. Entwisle, now Professor in Physics. Syracuse University is represented by Vernon T. Stewart, Professor in Chemistry and James C. Peet, Professor in Electrical Engineering.

It is interesting for us to note that these men all came with us in the very early days of the College, and their progress has paralleled that of the institution to a very remarkable degree. All of these men except Professor Bradley, who is Dean of the College, are heads of their professional departments. When they first came to Newark, the total student enrollment was 35, while the figure with this year's classes enrolled is 835.

PROGNOSTIC TESTS

TRYING TO FIND WHAT A STUDENT WILL DO LONG BEFORE HE DOES IT

By FRANK N. ENTWISLE, C.E.

Professor in Physics, Director of Curriculum, Newark College of Engineering

One of the functions of the office of the Director of Curriculum is to concern itself with the development of tests and examinations of an extra-curricular nature; i.e., not given in a regular course. Because of the increasing attention given to these devices in many Engineering Colleges a short discussion of the purpose of these tests and of the use made of the information derived from them may be of interest.

Tests and examinations "in course" are commonly given to determine the extent to which a student has mastered the subject. We speak of this as the extent of his "achievement." Tests may have an additional meaning, however. The successful completion of a task indicates a probable capacity to continue, as well. In this sense an examination may be regarded as a means of forecasting the success which may be expected in the new task.

Success is more likely to come if the new subject does not vary much from the old one, or is composed of ideas which have been met with to some extent in the former one. Likewise an examination is best adapted to prognosis when it too contains elements which are likely to occur in the new field. For example, a student who passes a satisfactory test in elementary mechanics is likely to do well in professional courses in which a well developed awareness of these principles is a necessity.

The tests upon which this office has been working are expected to supply data which will supplement the information to be obtained from the student's scholastic record. In the main they touch his mental activities only, and at three points in his sub-professional years. Taken in chronological order they are:

1. A test to measure sensitivity to mechanical motions and devices. For this purpose, use has been made of the exhibit of mechanical motions in the Newark Museum, through the courtesy of Miss Beatrice Winser, Director, and the kind assistance of the Museum staff. A control test is given at the same time using certain of the art objects in the Museum, to obtain the reactions of the student to widely different stimuli.
   These examinations would normally be given soon after the beginning of the Fall term, in Freshman year.

2. En Masse Oral Tests.

   These have been given at the conclusion of definite sections in the subject of Physics. They are an attempt to recapture some of the values inherent in oral response, as distinguished from responses made with visual aids, i.e., working out the problem in the usual way with paper and pencil. This type of test, familiar to all who remember the "mental arithmetic" of their primary school days, is not generally used in work of college level because of the difficulty of securing comparable results from a large class. Means have been devised to overcome this objection, and encouraging results have been obtained.

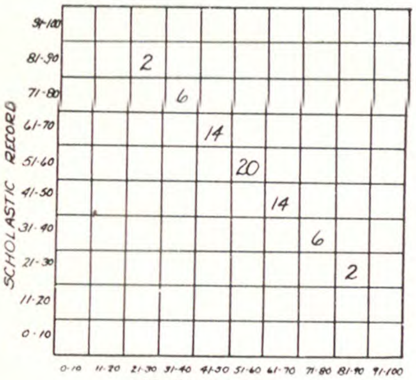
3. A Comprehensive Examination given at the end of the Sophomore year to all candidates for promotion to the first professional year. This test is not a resume of the subject matter of the first two years, but is probably best described as a Scholastic Aptitude Examination adapted to Engineering students. It aims to classify students in the order of their ability to synthesize the facts of mathematics and physics, apply their knowledge of these facts to the solution of common engineering situations, and to discuss these facts in reasonably clear and precise English.

Inasmuch as these tests are used for prognostic purposes alone, it follows that the material of the test must contain the elements which will reoccur in subsequent courses. (An examination in Greek prose might be a good measure of achievement in Greek but could not be expected to furnish much information about a student's subsequent performance in Thermodynamics.)

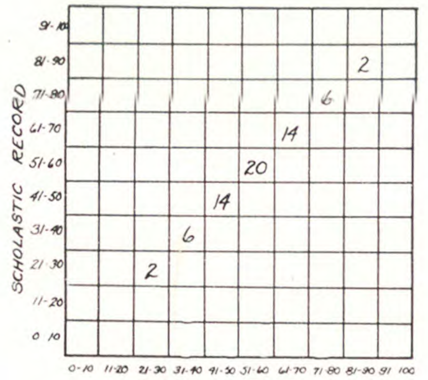
The elements from which any technical professional course is built are mathematics, physics, and chemistry with the greatest emphasis to be placed on physics. Consequently each of the three tests already constructed leans heavily upon elementary physical concepts.

A continuing study is made of each test to check its validity, and the chief tool in this attack is the correlation found between the marks made by a student in a given test and in his scholastic work.

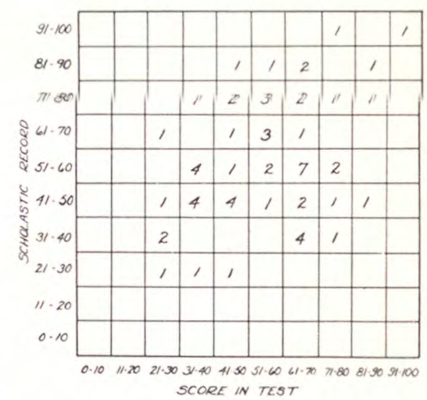
In practice, this is done for an entire



Perfect Negative Correlation
Coefficient = — 1.0



Perfect Positive Correlation
Coefficient = + 1.0



Actual Correlation
Coefficient = + 0.362

group, say 60 to 200 men, at one time and a sort of mean correlation coefficient established. If the results agree completely, an almost unknown circumstance, the coefficient is styled +1.0. If complete disagreement occurs, (unlikely) the coefficient of correlation would be —1.0. If the preponderant tendency is toward agreement, the coefficient would be expressed by some decimal between 0.0 and +1.0.

The typical sketches following show:

a. Complete agreement (within 10%) for a group of 64 men whose marks are correlated; and

b. Complete disagreement.

As an example of an actual plot, here is the relation between marks made by a number of men in Test No. 2, during their Freshman Year, and their average subsequent performance, in *all* subjects through the remainder of their four year course.

Here the coefficient of correlation is about 0.36, a fair but not an outstanding agreement.

Each of these three types of examination is original with the Newark College of Engineering. They represent an attempt to deviate from the beaten track and develop a test to suit circumstances rather than to adapt a nationally known test to the case in hand.

Progress is necessarily slow in an endeavor of this kind. Tests 2 and 3 have been in use for five years. Test 1 is a more recent development. Each will receive a more detailed treatment in this magazine at a later date.

Editor's Note: Professor Franklin N. Entwisle was graduated as a Civil Engineer from Princeton University in 1912. *He was elected to Phi Beta Kappa, honorary scholastic fraternity. During the years* 1912-18 *he served in the U. S. Engineer Corps, U. S. Army, as designer of steel and concrete structures; engineer in charge of surveying parties in New York Harbor, and in research work on tidal flow in New York Harbor.*

1919-21 *Was employed with Transmarine Corporation in the design of marine terminals.*

1921-22 *Taught Mechanical Drawing in Mt. Vernon, New York.*

1922 *Was appointed Instructor in Physics at Newark College of Engineering. Was later advanced thru the grades of Assistant, and Associate to the rank of Professor in Physics in* 1927. *At present holds this position together with the titles of Director of Curriculum, and Director of Athletics.*

Has written three textbooks in use at Newark College of Engineering—"Physics Laboratory Manual", "Elementary Statics", "Elements of Sound and Light."

He is a member of the Society for the Promotion of Engineering Education, Chairman of the local branch of this Society. A member of the American Physical Society, and of Phi Beta Kappa Alumni of New York.

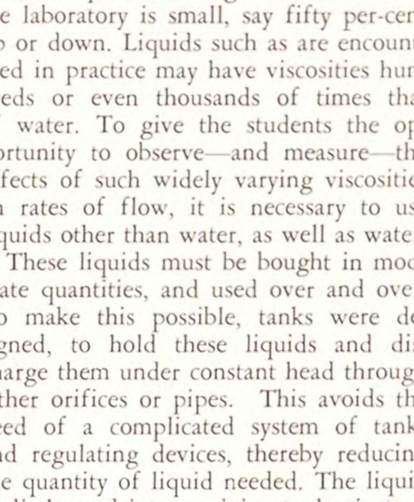
CONSTANT HEAD TANKS FOR HYDRAULIC LABORATORY

By H. N. CUMMINGS, A.B., S.B.

Professor of Civil Engineering, Newark College of Engineering

In planning a laboratory course for civil engineering students at the Newark College of Engineering, to accompany their introductory study of hydraulics, it seemed desirable to include some study of the effect of viscosity on fluid flow. Liquids other than water are comparatively expensive, particularly when considerable quantities are used by each student and then thrown away, that is, discharged into the sewer as is done with water. Although the viscosity of water can be varied by changing its temperature, the practical range of variation in the laboratory is small, say fifty per-cent up or down. Liquids such as are encountered in practice may have viscosities hundreds or even thousands of times that of water. To give the students the opportunity to observe—and measure—the effects of such widely varying viscosities on rates of flow, it is necessary to use liquids other than water, as well as water.

These liquids must be bought in moderate quantities, and used over and over. To make this possible, tanks were designed, to hold these liquids and discharge them under constant head through either orifices or pipes. This avoids the need of a complicated system of tanks and regulating devices, thereby reducing the quantity of liquid needed. The liquid is discharged into receiving tanks, instead of going into the sewer, and is later poured back into constant - head tanks. The tanks in use at present are rather small—experimental size—but the results obtained from them seem to justify trying larger sizes in order to get a wider range of performance.



Constant Head Water Tank

The sketch shows the design, with the dimensions of the experimental tank that is at present being used. Galvanized sheet-iron was used for the tank itself, which is air tight excepting as shown.

A is the opening for filling the tank. It is closed by a threaded stopper.

B is a ⅝ inch brass tube, open at both ends. Pipe can be raised or lowered, but must fit at *G* tightly enough to prevent air leaks.

C is a gage glass for measuring contents of tank. It connects with the tank interior at top and bottom.

D is the discharge fitting. A short tube fitted tightly into the wall of the tank, with flanges between which brass orifice plates can be clamped. Outer flange opening is threaded so that a section of brass pipe can be attached for study of flow through pipes. A valve is located between the tank and the flanges.

E is an open glass pressure-head gage tube, showing the static pressure just back of the orifice.

To operate the tank, the tube *B* is raised or lowered until its lower end is at a distance above *D* about equal to the "head" desired for the run (There must be sufficient liquid in the tank, *above* the lower end of the tube *B*, to supply the quantity required for the run.) When the valve at *D* is opened and liquid begins to flow, the column in the pressure-gage tube *E* rises to the level of the liquid in the tank shown by gage *C*. As liquid continues to flow the pressure head decreases until the level of the liquid in *E* is approximately the same as that of the bottom of tube *B*. From that time on, the pressure head remains constant (so long as there is sufficient liquid in the tank to cover the bottom of tube *B*) and an observation can be made of rate of flow through the orifice or pipe for the particular liquid in the tank under the observed head.

Editor's Note: Harold Neff Cummings, Professor of Civil Engineering, was born and brought up in Maine. After graduating in 1906 *from Bates College, he left the state and served two years as Instructor in Science at Worcester (Mass.) Acadamy. Two more years in Boston at Massachusetts Institute of Technology gave him a B.S. in Civil Engineering. A year as instrument man and computer for a firm of civil engineers in Hartford, Conn. was followed by three years as Principal Assistant Engineer in the Engineering Department of the Great Northern Paper Co. at Millinocket, Maine. Following this brief return to his native state, he served as Head of*

(*Please, turn to page* 11)

THE EQUILIBRIUM OF A RECTANGULAR, HORIZONTAL PIECE OF CANVAS UNDER WATER PRESSURE

By JOSEPH JOFFE, Ph.D.

Assistant Professor in Mechanics and Chemistry, Newark College of Engineering

The canvas forms the bottom of a tank, as shown in figure 1. It is supported along the edges A'D' and B'C' only, while the faces AA'BB' and CC'DD' of the tank are extended to meet the canvas and constitute a closed tank. The problem is to determine the shape of the surface assumed by the canvas when the tank is filled with water at rest.

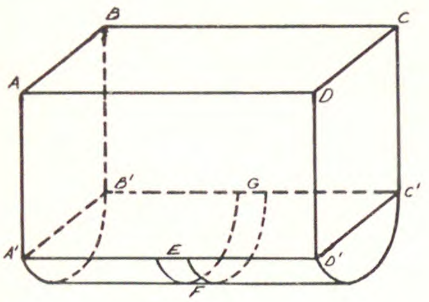


Figure 1

The student is perhaps already familiar with the problems of the parabolic cable and the catenary. In the first case a vertical load is distributed uniformly along the horizontal, in the second case uniformly along the cable itself. Our present problem leads us practically to a cable under a load which is everywhere normal to the cable.

Appell in his "Traite' de Mechanique Rationelle" has already obtained a solution of the problem in parametric form with the aid of advanced methods. It is our object to show how the problem may be solved by means of elementary considerations within the reach of the student of a first course in mechanics and the calculus.

Obviously, the equilibrium form of the canvas is a horizontal cylinder. To determine the nature of this cylinder we consider a band of canvas EFG of unit width, lying between two right sections of the cylinder, as shown in figure 1. Divide the band into strips of length Δs, the boundary between each two strips being taken along an element of the cylindrical surface. The forces acting on such a strip are shown in figure 2.

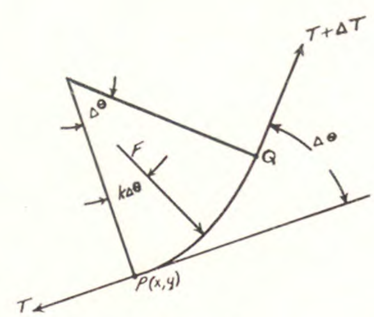


Figure 2

Let the right section bounding the band EFG be taken as the X-Y plane, the X-axis lying in the surface of the liquid and the Y-axis perpendicular to it, passing through the lowest point in the canvas. The force F exerted on the strip PQ (fig. 2) by the water is equal to $wy\Delta s$, where w is the density of the water, y the depth below the surafce, and Δs the area of the strip. T and $T+\Delta T$ are the tensions at the two ends of the strip. θ is the inclination of the curve PQ at P. k must have some value between 0 and 1.

Resolving the forces along the tangent and normal at P, we obtain the following equations of equilibrium for the strip PQ:

$$(T+\Delta T)\cos\Delta\theta - T + wy\Delta s \sin k\Delta\theta = 0 \qquad (1)$$

$$(T+\Delta T)\sin\Delta\theta - wy\Delta s\cos(k\Delta\theta) = 0 \qquad (2)$$

We have from (1):

$T(\cos\Delta\theta - 1) + \Delta T\cos\Delta\theta + wy\Delta s \sin(k\Delta\theta) = 0$, and since $\cos\Delta\theta - 1 = -2\sin^2\dfrac{\Delta\theta}{2}$, equation (1) becomes:

$$-2T\sin^2\frac{\Delta\theta}{2} + \Delta T\cos\Delta\theta + wy\Delta s\sin(k\Delta\theta) = 0.$$

Dividing by Δs,

$$-2T\frac{\sin^2\frac{\Delta\theta}{2}}{\Delta s} + \frac{\Delta T}{\Delta s}\cos\Delta\theta + wy\sin(k\Delta\theta) = 0.$$

Passing to the limit and remembering that

$$\lim_{\Delta s\to 0}\frac{\sin^2\frac{\Delta\theta}{2}}{\Delta s} = \lim\left(\sin\frac{\Delta\theta}{2}\cdot\frac{\operatorname{Sin}\frac{\Delta\theta}{2}}{\frac{\Delta\theta}{2}}\cdot\frac{1}{2}\frac{\Delta\theta}{\Delta s}\right) = 0.$$

$$\lim_{\Delta s\to 0}\cos\Delta\theta = 1$$

$\lim\limits_{\Delta s\to 0}\sin(k\Delta\theta) = 0$, we obtain the result:

$$\frac{dT}{ds} = 0,$$

$$T = \text{a constant.} \qquad (3)$$

Hence, equ. (2) reduces to:

$T\sin\Delta\theta = wy\Delta s\cos(k\Delta\theta)$,

or $T\,.\,\dfrac{\sin\Delta\theta}{\Delta\theta}\,.\,\dfrac{\Delta\theta}{\Delta s} = wy\cos(k\Delta\theta)$.

Passing to the limit and remembering

that $\lim\dfrac{\sin\Delta\theta}{\Delta\theta} = 1$, $\lim\cos(k\Delta\theta) = 1$,

we obtain:

$$T\frac{d\theta}{ds} = wy, \text{ or}$$

$$\rho y = \frac{T}{w} = \text{a constant,} \qquad (4)$$

where ρ = radius of curvature $= \dfrac{ds}{d\theta}$.

Setting $\dfrac{T}{w} = K$, we have: $\rho y = K$, (5)

the differential equation of the right section of the cylinder.

It follows that

$$\frac{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{3/2}}{\frac{d^2y}{dx^2}}\cdot y = K$$

Setting $\frac{dy}{dx} = p$, we have

$$\frac{d^2y}{dx^2}=\frac{d}{dy}\left(\frac{dy}{dx}\right)\cdot\frac{dy}{dx}=p\frac{dp}{dy}$$

Hence, $[1+p^2]^{3/2}\, y = Kp\frac{dp}{dy}$.

$$2ydy = K\frac{2\,p\,dp}{(1+p^2)^{3/2}}$$

$$y^2+c = -\frac{2K}{(1+p^2)^{1/2}},$$

c a constant of integration.

$$1+p^2=\frac{4K^2}{(y^2+c)^2}$$

$$p=\frac{dy}{dx}=\sqrt{\frac{4K^2}{(y^2+c)^2}-1}=$$

$$\frac{\sqrt{4K^2-(y^2+c)^2}}{y^2+c}$$

$$dx = \frac{(y^2+c)\,dy}{\sqrt{4K^2-(y^2+c)^2}}$$

$$x = \int\frac{(y^2+c)\,dy}{\sqrt{4K^2-(y^2+c)^2}}.$$

This is the rectangular equation of the right section of the cylinder. The integral appearing in this equation is an elliptic integral and cannot in general be expressed in terms of elementary functions.

If the sag in the canvas is small in comparison with the depth of the water filling the tank, we can obtain an approximate solution of the problem as follows: Consider y a constant in equ. (4). It follows that ρ is a constant, and hence the right section of the cylinder is a circle.

Assuming a circular section, we derive a relation between the sag f of the canvas and the tension T. In fig. 1 let AB= 2l and AA' = h.

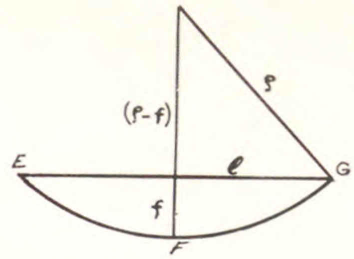


Figure 3

From fig. 3:

$$(\rho - f)^2 + l^2 = \rho^2$$

Hence, $\rho = \frac{f^2+l^2}{2f}$

By equ. (4):

(7) $T = wy\rho = wh\left(\frac{f^2+l^2}{2f}\right)$

Thus, if the tank is 6 ft. wide and is filled with water to a depth of 4 ft., assuming a sag of 3 in., we obtain the following value for the tensile stress in the canvas:

$$T = 62.5 \times 4 \times \frac{\frac{1}{16}+9}{\frac{1}{2}} =$$

4530 lb. per ft. = 377 lb. per in.

We see from equ. (7) that for a small sag the tensile stress is approximately inversely proportional to the sag.

Editor's Note:

J. JOFFE *was born October* 27, 1909. *He was a student at Columbia University from* 1926 *to* 1933, *and while there held a Pulitzer scholarship* (1926-1930) *and a University fellowship in chemistry* (1931-1932). *He received the degree of A. B. in* 1929, *B. S. in engineering in* 1930, *M. A. in physics in* 1931, *and Ph.D. in chemistry in* 1933. *He is a member of Phi Beta Kappa and Sigma Xi. He has been teaching at the Newark College of Engineering since* 1932. *He is married, and resides at* 240 *Waverly Place, New York City. He is especially interested in the modern developments in physics and chemistry and likes to follow them in his leisure time.*

A NEW PHYSICS TEXT BOOK

Reviewed by WILLIAM HAZEL, JR.

ELEMENTS OF SOUND AND LIGHT —First edition by Franklin N. Entwisle, Professor of Physics, Newark College of Engineering. Stiff binding; $8\frac{1}{2}$ x 11 in.; pp. 89; numerous diagrams and illustrations. Published by Newark College of Engineering. Price $1.

In order that all of the branches of Physics may be covered in an elementary physics text it is necessary for the authors to eliminate certain explanations, methods, or even delete certain parts of basic physical theory. Authors that attempt to provide adequate coverage find their volumes too large for general use. For this reason the average physics textbook is generally lacking in a complete discussion of the Elements of Sound and Light, and it is to supply this need that this text is provided. The book was especially written to provide the student with a basis of knowledge in two branches of physical science in which he will receive little other training in his engineering education unless a special effort is made.

Wave Motion is described and the elementary wave equations are given. The generation of Lissajou figures is demonstrated and the derivation of the equations for waves in a string are shown.

The section on Sound discusses Speech and Hearing, Loudness (including the elusive decibel), Music, Pipes and Strings, and Acoustics.

The section on Light fills the major portion of the book and adequately covers the field from Illumination through interference, Diffraction, and Polarized Light.

The problems are numerous and offer excellent applications of the principles discussed. As the text states "The Problems in Sound and Light which are given here follow conventional patterns in most instances."

Since the book is essentially a "work book" it is bound so as to lie flat on the table. Its format is attractive and durable.

Not only is this book an excellent supplementary text, but it also would be an excellent reference on the "Elements of Sound and Light." It provides all of the necessary information that the author's teaching experience and study has shown to be necessary for this part of a basic physics course for engineers.

A GOOD RECORD

The professorial staff at the Newark College of Engineering totals twenty-nine men. Of this number, fifteen, or more than fifty per cent, are listed in "Who's Who in Engineering." They are:

ALLAN R. CULLIMORE
JAMES C. PEET
HAROLD N. CUMMINGS
VERNON T. STEWART
J. ANSEL BROOKS
FRANK N. ENTWISLE
ALBERT A. NIMS
FRANK D. CARVIN
PAUL M. GIESY
JAMES A. BRADLEY
WILLIAM S. La LONDE
HENRY H. METZENHEIM
JAMES M. ROBBINS
PAUL C. SHEDD
SOLOMON FISHMAN

RETROSPECT AND PROSPECT

By ROBERT W. VAN HOUTEN, B.S., C.E.

Assistant Professor In Civil Engineering, Newark College of Engineering

As President Cullimore mentions in his diary, I am sketching for the benefit of the Alumni the progress of our enrollment in the College since its foundation nearly nineteen years ago.

I think, in the first place, we should appreciate that the growth of an institution during the first years following its foundation must necessarily be more rapid than its growth a little later in its history.

We have passed through the phase of construction, the phase of recruiting a student body, and are now in that phase of development which concerns itself primarily with stabilizing things, with surveying the situation and deciding not only the numbers which are best suited to our physical facilities, but also with certain quantitative considerations which have to do with the development of one course as against another, and the development of something of a scientific sensitivity.

We are properly concerned with many of these things which are fundamental in growth and have nothing to do with the number of students as such, but it is certainly very interesting and worth while to point out to those Alumni, particularly those who have not been in close touch with us for some time, the progress of our enrollment.

The Start and Growth

In September, 1919, twenty-three students registered in the Newark College of Engineering and formed the first class. For the next three years classes were successively added until in 1922 we had Freshmen, Sophomores, Juniors and Seniors, that is, a curriculum operating in all four years with a total of ninety-three students. Five years later the registration had grown to 272. Another five years passed and the enrollment was 626, and last September, fifteen years after college work was given in all four years, the enrollment was 835, making an increase of nearly 800 per cent above the enrollment in 1922. This of course includes that group of young men who are taking the Junior and Senior work which is repeated in the evening.

I think we of the Alumni could feel justly proud of this progress as regards numbers, but we should keep in mind that numbers of course do not tell the whole story. It is however of interest to us to know that our college now has not only the largest enrollment of any engineering college in New Jersey, but also has one of the largest in the metropolitan area.

The Future

This gives you a rough idea of what has happened to us as far as numbers are concerned and there is, of course, an urge to predict what the enrollment would be in the future, that is, five or ten years in the future. This prediction however in our case depends upon a number of factors of which I want to mention one or two. The first is that our physical plant is working and has been working to capacity. We might say that it has been working of late years a little over capacity, and provided our present physical facilities are not increased it will be necessary to cut down on the enrollment rather than to increase it.

It is also interesting to note that the administration, including the Board of Trustees, is not particularly interested in numbers as such. Their function as they see it and as I understand it is to reasonably fill a definite local need, and the whole spirit of the institution is to give increasingly better work rather than to give more of it.

Therefore, while you have seen a very considerable growth in numbers in the past, the future will probably be characterized by a very definite attitude of consolidation, increase of quality, and with perhaps a consequent fall in total overall enrollment. I think it is the feeling of the Board as well as the Faculty that quality rather than numbers should be the criterion.

Selection of Students

The question of the selection of students of course arises, and it is particularly true that in a publicly supported institution more than ordinary care must be given to securing those individuals who have capacity and intelligence enough to not only profit by the experience themselves but to return some of it in the form of general community benefit. For this reason the two basic considerations are the need for help and the capacity to profit by it. We feel that no man should be given an education at the expense of the City or the State unless he needs the help and that need must be coupled with the individual's capacity to profit by it.

With these things in view, and with the necessity for at least holding level and perhaps cutting enrollment, a policy of interviewing each applicant for the class of September, 1938, has been instituted. In this way we believe that many students will be prevented from drifting into engineering without any particular aptitudes and interests. By advising them to seek their future in some other field we may prevent misfits and also give some guidance and suggestions to those who really can receive benefit from it.

Our enrollment will further be controlled by limiting the number of applicants to be accepted. For instance, in the Department of Industrial Chemistry this year we plan to limit to fifty-five the number of first year students in Industrial Chemistry who will be admitted in September, 1938. Already our applications for 1938 are more than 75 per cent ahead of what they were at this time last year. In the case of this limitation, advanced tuition deposits will be required so that only those who are definitely interested in entering the College will be placed upon the eligible list.

In looking at the situation, over the past nineteen years, it has been characterized by a very considerable, perhaps more than average, increase in enrollment. One of the factors which made this possible was the general knowledge concerning the work of the Newark Technical School, the parent institution.

The work of that institution which has been given for so many years along technical lines give us to start with a reputation which was pretty widely known throughout this locality.

Sometimes it has been a little hard for people to see just how the College fitted in with the Technical School as they have been together under the same management with a common philosophy and a common administration. It would seem, looking from the outside in, as if the Technical School has helped the College much in the past and would help in the future, and that the College at the present time is paying back, somewhat in the way of reputation and prestige, to the Technical School advances made in the past.

The Technical School too has changed considerably in the past twenty years and I hope that sometime in the future an article will be published concerning its enrollment and some of its values.

THE WAY WE SEE IT

Our Introduction

The first issue of the Newark Engineering Notes is now before you. The entire staff of the Newark College of Engineering is very much interested in the successful development of it.

Your cooperation would be appreciated in helping to create a first-class technical magazine.

Here is what you can do:

1. Report your impression of the magazine, criticize it, especially constructively, and make suggestions.

2. Give us some other contributions, for instance a technical article concerning your professional work, a thesis you may have written for an advanced degree, or a paper you may have presented before one of the professional engineering societies, or had published in one of their periodicals.

* * * *

Always remember that Newark Engineering Notes represents your school, and that its success will be to your advantage.

* * * *

The policies governing the Newark Engineering Notes are not completely determined yet. For the time being your magazine will give you, among other things, news about the activities of N. C. E. graduates. You will be interested in learning what your friends of college days are doing now, what progress they have made professionally, and whether they still reside in the old home town. In addition, you will surely want to know what ones among them have entered the happily married state.

The College has undergone a great many changes in the past few years. Additional equipment of the most modern type has been installed in our laboratories. In this magazine some endeavor will be made to acquaint you with these changes, what they mean to the College as a whole and how important they are as a contribution to the growth of the entire Institution. And of course, it will always be interesting to read the news about the professors and their activities.

The magazine will also offer engineers and students opportunities to have published their original technical papers on various subjects in engineering.

* * * *

What can be done to help your school?

Have you any suggestions to offer that are beneficial to the Newark College of Engineering and the Newark Technical School?

Here might be one:

The subway going out from Pennsylvania Railroad station has the third stop marked "Warren Street." As this station is only three short blocks away from our school, it is suggested that this station be called "Newark College of Engineering."

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Mr. Martin Matheson of John Wiley & Sons, Inc., reported to the Editor some time ago: "Judging by the sales of engineering textbooks, Newark College of Engineering must be one of the largest engineering schools in the country."

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Mr. Lawrence E. Widmark, Chief Engineer of Star Electric Motor Company, expressed lately some favorable comments about Newark College of Engineering, because one of the professors had helped him to solve a highly technical problem.

Editor's Note: Professor Robert W. Van Houten, born 1905 *in Newark, New Jersey, was graduated in* 1924 *from the Newark State Normal School having majored in Industrial Arts. The next two years were spent teaching in the public schools of Essex Fells and Roselle and in September* 1926 *he entered the Newark College of Engineering being graduated in* 1930 *with the degree of B.S. in Civil Engineering. During this period he did cooperative research work for the Wallace and Tiernan Company of Belleville and the A. C. Windsor Construction Company of Newark. In September* 1930 *he was appointed to the position of Instructor in Mathematics in the Newark College of Engineering, the following September, to the position of Instructor in Civil Engineering, and in June* 1932 *he received, from the Newark College of Engineering, the professional degree of Civil Engineer. In* 1934 *he was given charge of the Summer Session of the College and in* 1936 *he was also appointed Assistant Professor in Civil Engineering. He is a Member of the Society for the Promotion of Engineering Education, an Associate Member of the American Society of Civil Engineers, an Engineer Member of the Society of American Military Engineers, and a Member of the Society of the Trunnion.*

CONSTANT HEAD TANKS FOR HYDRAULIC LABORATORY

(Continued from Page 7)

the Civil Engineering Department at Mechanics Institute, Rochester, N. Y.,—Head of Mathematics Department at Lynn (Mass.) English High School,—Acting Head of Mathematics Department at Wentworth Institute, Boston, Mass.,—and Associate Professor of Civil Engineering at the University of Delaware. In 1920 *he came to Newark as Professor of Applied Mathematics in the newly organized College of Engineering. When the civil engineering course was added to the curriculum in* 1927, *he became Professor of Civil Engineering and Head of the Department.*

Throughout the time spent in educational work he has carried on an incidental private practice. His hobby is camping, which takes him back, whenever he has time, to Maine, where he has a camp on Gardner Lake in East Machias. He is a Member of the American Society of Civil Engineers, Military Engineer Member of the Society of American Military Engineers, Fellow of the American Geographical Society, Member of the Society for Promotion of Engineering Education, the American Association for the Advancement of Science, American Association of University Progressors, and Phi Beta Kappa.

WHAT OUR PROFESSORS AND GRADUATES ARE DOING

Harry Burrell, a graduate of Newark College of Engineering, now with the Ellis-Foster Company, Montclair, N. J., had an interesting article published in Industrial and Engineering Chemistry for March 1938.

Under the heading "Organolites-Organic Base-Exchange Materials" Mr. Burrell offers a theory of base-exchange activities and suggests several practical applications.

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George C. Keeffe, a graduate of the Newark College of Engineering in 1932 and an Instructor in Chemical Engineering at the College since 1936, holds an industrial fellowship for research in the chemistry of alkaloids as part of the requirements for the degree of Doctor of Philosophy at New York University. Mr. Keeffe received the degree of Ch.E. from the Newark College of Engineering in 1935 and an M.S. in Chemistry from New York University in 1936.

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George D. Wilkinson, Jr., Assistant Professor in Industrial Engineering, graduated with a degree of B.S. in M.E. from the Newark College of Engineering in 1933 and in 1937 received an M.S. in Industrial Engineering at Columbia University. The title of the thesis for the latter degree was "An Economic Survey of the Motor Trucking Industry."

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Associate Professor Paul M. Giesy, of the departments of Chemistry and English, Newark College of Engineering, has again been appointed a member of the Consulting Board of the Institute of Cancer Research of Columbia University, having held this appointment for twelve years. Dr. Giesy's connection with this work dates from 1916, when he began the chemical work for the Institute which later was the basis of his dissertation for the degree of Doctor of Philosophy at Columbia University. Other members of the Consulting Board are Dean George B. Pegram and Professor Bergen Davis, of the Department of Physics, Columbia University, Professors M. T. Bogert and H. C. Sherman, of the Department of Chemistry, Columbia University, and Professor Thomas Hunt Morgan, of the California Institute of Technology. Professor Morgan was awarded a Nobel prize in 1933 for his work in genetics.

The total edition of the first issue is 4,000 copies, to be mailed to all graduates, all engineering colleges and technical schools in U. S. A., to professional engineers in the State of New Jersey, leading industries, etc.